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Using a waste in asphalt mixtures – a laboratory investigation

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1. ABSTRACT.

Waste management is an actual problem that involves a lot of participants. Road safety and its maintenance is a permanent preoccupation for road administrators. The idea of incorporating a waste came out after we fund a powder obtained after a recycle process of electrical equipments-PBC. Our preoccupations are orientated over asphalt pavement performance and new raw materials that can be use with success in road asphalt pavements. To study the feasibility on using this waste in asphalt pavement industry we have made a serial of laboratory investigation over one asphalt concrete BA16 rul 50/70 (AC16) that is a standard asphalt mixture in Romania, according to AND605/2016. Tests were cyclic compression-dynamic flow, rutting test, Marshall Stability and flow. On the additional waste that substitutes limestone filler, we also made some laboratory analysis to see the composition. The conclusion after the first experimental stage is that the mixture is softer that the control/witness mixture.

2. INTRODUCTION

This paper addresses the problem of using recovery materials such as PCB (Printed Circuit Boards) to substitute filler in asphalt mixtures. PCB consists of metals and non-metals from electronic waste by physical and chemical recycling process so called E-Waste. The raw material we used in laboratory investigations was a mix obtained by recycling electronic waste - PCB. X-ray diffraction was performed to see the composition of the new material, including E-waste (FIG.1)

3. DISCUSSION AND RESULTS

Table 1 reveals that in the new waste, the non-metals represent the majority share. This can lead us to believe that on the market exist different types of PCB made by different materials. In our case, Carbon is having the bigger influence up to 72.7% from the waste mass.
The granularity of the waste is compared with filler (Table 2). Our target is to substitute if we can the filler from the asphalt mixture.

Table 2. PCB versus lime filler

Lab.test	*PCB*	Filler	*Standards*
Granularity [mm]	%	%	
1	99.3	100	SR EN 933-10:2009
0.63	90	100	
0.25	62.7	99.8	
0.125	53.2	93.9	
0.063	44.1	79.9	
0.02	17.2	18.9	
Humidity			
Max.2%	1.44	0.12	STAS539/79
Apparent density			
0.5-0.8g/cm^3	0.48	0.54	
Hydrophilicity coefficient			
Max.1cm^3	0.78	0.28	STAS539/79
Voids content			
range 0.3-0.5%	0.82	0.41	STAS539/79

Asphalt mixture design

The asphalt mixture design was made according to European standards (EN), SR EN 12697 and AND 605-2016 that guide us in Romania. We have made a mixture for the final course layer – top layer – that is the most expose to traffic and climatically changes from all road structure. Name of the layer according AND605-2016 is BA16rul50/70.

BA 16 rul 50/70 means: the maximum size of the aggregates is 16mm, rul - came from the wearing layer (the final one) and 50/70 is the binder/bitumen type. Bitumen 50/70 is the most commune asphalt binder used in Romania.

The mixture recipe of BA16 rul 50/70 is presented in the following tabel:

Material-granular and binder	%
0-4mm	42.48
4-8mm	23.6
8-16mm	19.82
Lime filler – pcb	8.50
Bitumen	5.60

The amount of PBC is equal with filler one.

Lab.test	**BA16 Rul50/70 PCB**	**BA16 Rul50/70 Filler**	Standards
Marshall Stability	**10.7**	**11.3**	SR EN 12697-34:2012
Flow	**8.7**	**3.3**	SR EN 12697-34:2012
Density	**2129**	**2399**	SR EN 12697-6:2012
Water absorption	**7.3**	**2.4**	AND605:2016d
Void content	**8.5**	**2.7**	SR EN 12697-5:2012

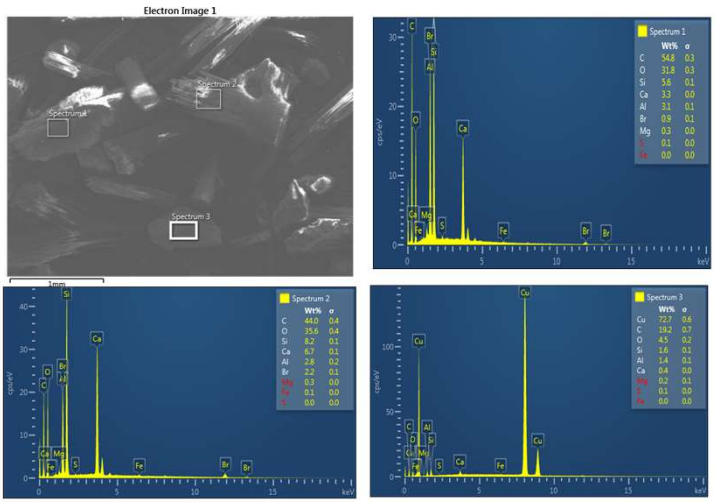


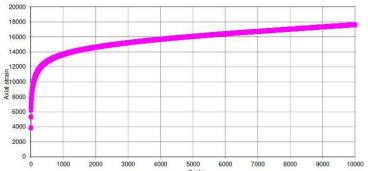
FIG.1 X-ray diffraction of the new material including E-waste.

Table 1. PCB material composition - our waste

Non-metals About 93.40%	%	Metals About 6.60%	%
C	44-72.7	Ca	1.6-6.7
O	19.2-35.6	Al	1.4-3.1
Si	4.5-8.2	Mg	0.2-0.3
Br	0.4-2.2	Fe	0.00
S	0.1		

BA16rul50/70filler samples have: 101.1mm diameter, 63.2mm high. The cyclic load is setup at 300kPa, temperature 50°C, frequency 3Hz, lateral pressing 150kPa and 10.000pulses.

BA16rul50/70 PCB samples have: 100.2mm diameter, 63.6mm high. The cyclic load is setup at 200kPa, temperature 40°C, frequency 3Hz, lateral pressing 150kPa and 10.000pulses.



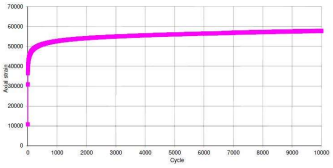


Table 4. Dynamic flow-Cyclic compression for BA16 rul 50/70 with PCB

	Determination	MU	Result	Standard method
1	Deformation speed at 40°C at 10000 pulses	µm/m/cycle	0.51	SR EN 12697-25:2016
2	Deformation at 40°C at 10000 pulses	µm/m	55718	SR EN 12697-25:2016

Table 5. Rutting behaviour

	Test	*m.u*	Result BA16 rul 50/70 Filler	BA16 rul 50/70 PCB	Standard method
1	Deformation speed WTS_{AIR}	mm/10^{3}cycle s	0.16	0.35	SR EN 12697-22+A1:2007
2	Proportional Rut depth PRD_{AIR}	%	4.6	14.1	SR EN 12697-22+A1:2007
3	Rut depth RD_{AIR}	mm	1.82	5.63	SR EN 12697-22+A1:2007

4. CONCLUSIONS

Making a comparison between the witness mixture- using filler and the eco one- using PCB waste, we can say that according to AND 605:2016 the eco mixture can't be use like asphalt pavement for vehicle use.
After the basic experimental set: Marshall flow and stability, density, water absorption and void content, we can say that both asphalt mixture are having good properties.
Regarding dynamic tests, there were differences between the two mixtures are important.
The difference for the dynamic flow is: 17602 µm/m for the filler one face to 55718 µm/m for the PCB one. That means a dynamic flow modulus 3.16 time bigger for PCB mixture and this is not a good thing.
In terms of rutting the difference, stays like for the dynamic flow. Rut depth is 3.09 bigger for PCB mixture.
That means our eco mixture – is not proper to use like asphalt pavements on roads. Is proper to use on pedestrian or bike areas, were the asphalt mixture has a different role.